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An experiment was conducted comparing the abilities of normal and retarded third-, fourth-, fifth-, and sixth-grade readers to report the temporal and spatial order of presentation of letters. The presentations were accomplished by using animated techniques on motion picture film. It was found that while the retarded readers were inferior to the normals on reporting spatial order, they were not generally inferior on reporting temporal order. The findings do not support the idea that reading disability is due to a difficulty in perceiving or recognizing letters or words. However, they do reveal that one of the principal difficulties in reading is due to an inability to mentally reorganize experiences obtained in time into their proper spatial arrangement. References are included. (RT)

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## ABSTRACT

An experiment was conducted comparing normal with retarded readers on their ability to report on the temporal order of presentation of letters and their ability to report on the spatial order of letters. The presentations were accomplished using animated techniques on motion picture film.

It was found that while the retarded readers were inferior to the normals on reporting spatial order, they were not generally inferior in reporting temporal order.

The finding gives little encouragement to the belief that reading disability in subjects such as those obtained in the experiment is due to a difficulty in perceiving or recognizing letters or words per se, but it does strongly argue that one of the principal difficulties in reading is due to an inability in mentally reorganizing experiences obtained in time into their proper spatial arrangement.

# SECTION I

# INTRODUCTION

Reading skill is a complex art which touches upon numerous factors, some of which are intrinsic to the individual, while others are environmentally produced. Difficulties in reading appear to be derived from causes that sometimes operate in isolation from one another, while at other times there is evidence that they act in a synergistic fashion. Among the more frequently sighted factors which are presumed to generate the population of poor readers are emotional, motivational, pedagogical, neurological, intellectual, developmental, sensory, and perceptual causes. Since these are not factors as much as broad descriptive areas which overlap with one another, it is evident that reading disability, from an etiological point of view, is a jungle into which only the most intrepid theoretician should venture.

These hazards notwithstanding there has been little hesitation on the part of educators and others in producing hypotheses relating to this problem. There exists a body of speculative literature, formidable in scope and content, which is based primarily on classroom and field observation. Happily, there is also beginning to be an accumulation, although relatively modest in magnitude, of experimental data on the topic. Despite these prodigious efforts, the subject has the aspect of an unweeded garden, with little theoretical systemization in evidence.

This situation has arisen, at least in part, from the fact that a disproportionately large effort has been expended on etiological classification to the relative neglect of obtaining an accurate description of what it is that poor readers do or fail to do. There are probably a number of characteristics that poor readers have in common despite heterogeneous histories and etiologies that may exist. It may at times also be the case that etiological

classification is of little therapeutic consequence.

One behavioral pattern that is frequently found in poor readers is the tendency to read letters or words in reversed or some other inappropriate order. This suggests that in these cases the difficulty is not one of responding improperly to a discrete stimulus but rather in failing to arrange the stimuli in their proper order.

It is known from photographs taken of eye movement during reading that fixations do not occur in an orderly sequence (Tinker, 1946). Not only does the eye not sample at equal intervals, but it does not always progress in a forward direction. It will look back, forward, up and down in a somewhat unpredictable manner. Since the eye is, in effect, blind during rapid movement (Dodge, 1905, Woodworth, 1906) and since peripheral vision is inadequate for most reading, it seems evident that the act of reading requires spatial as well as temporal organization. The events that occur in time must be perceptually reorganized into their proper spatial arrangement in order for the material to be understood. If it were the case that some individuals have difficulty translating things that happen in time into things that exist in space, it would be expected that they would have difficulty learning to read. Similarly, if this is one cause of reading disability, one would expect to find that as compared to normal readers, poor readers would find it relatively easier to report on the occurrence of things in time than on the arrangement of things in space. More specifically, if poor readers are compared with normal readers on their ability to report the sequence of occurrences in time, there will, according to this hypothesis, be little difference between groups. If, on the other hand, the groups are compared for their ability to report the order of things in space, there will be a significant difference in favor of the normal group. This especially will be the case when the temporal order of

presentation is at variance with the spatial order of position. This general relationship can be expressed in the following manner:

$$\frac{E_{RT}}{E_{RS}} < \frac{E_{CT}}{E_{CS}}$$

where E = mean number of errors

R = retarded reading group

C = normal (control) group

T = reporting temporal order

S = reporting spatial order

A still more specific statement of the hypothesis can be written

$$\left|E_{RT} - E_{CT}\right| < \left(E_{RS} - E_{CS}\right)$$

The left-hand term is written as a positive absolute difference, while the right-hand term is shown as an algebraic difference. In effect, this statement predicts that the difference in reporting temporal events will be small and random in character while the difference in reporting spatial order is predictably in favor of the normals. It is with this hypothesis that the present study concerns itself.

In perhaps a broader sense, the hypothesis touches upon two conceivable explanations for reading difficulty. One explanation is that the poor reader, for some reason as yet unaccounted for, does not perceive all of the letters, words, and sentence elements that are necessary for a reconstruction of the text. The alternate view is that while the reader does have perceptual access to the elements, he is, again for reasons unknown, unable to reconstruct time sequences into spatial sequences. Neither of the views, of course, entirely excludes the other, and it may be that both are involved and that their ratio of involvement varies from one poor reader to the other. The present hypothesis, however, does express the notion that the second factor exerts, at

least on the average, a greater interference than the first. The basis for this theoretical approach, aside from the observed tendency of poor readers to produce reversals, is derived from other studies reported in the literature relating to the temporal aspects of reading. The remainder of this section is devoted to describing briefly some of the studies that are relevant to the topic.

Errors in reading due to a tendency to reverse letters have been noted in the literature for many years and reported in many languages. There is on record as early as 1896 a short article by W. Pringle Morgan (Hermann, 1959) reporting the considerable number of reversals in reading displayed by a fourteen year old boy of normal intelligence. Since that time nearly every text on the subject makes some mention of the tendency to reverse as a factor in poor reading.

Explanations as to the possible cause of reversal errors are multitudinous. Harris (Krise, 1949) suggests that the problem is one of not having learned to look consistently at a word from left to right. Gates (Krise, 1949) feels that the techniques of studying and recognizing other objects may be faulty: the child may have learned to examine objects from right to left and that this persists in the examination of words or letters.

In his study of retarded readers, Orton (1937) also noted the correlation between reading retardation and the tendency toward reversals. He believed that behind this phenomenon there lay a faulty patterning of brain function, a physiological state of ambiguous occipital dominance, such that if a clear-cut unilateral dominance was not established there would arise a confusion which would prevent the immediately successive linkage of the visual stimulus with its meaning.

Investigators for many years have been concerned with a possible relationship between laterality and reading achievement. Studies have been

conducted in the areas of eye dominance, hand dominance and also in mixed dominance.

When Monroe (1932) analyzed the hand and eye preferences of 515 school children to determine the relationship between dextrality and reading difficulty she found no conclusive evidence that mixed laterality produces reading difficulties. She did note, however, a tendency for left-eyed children, whether mixed or pure dextrals, to make more reversals than right-eyed children. She offered the suggestion that the left-eyed child may tend to move his eyes to the left because his field of vision is relatively unimpeded in this direction, while being blocked by the bridge of the nose to the right.

Weintraub (1968) has reviewed recent literature in the field of eye-hand preference. He states that the data collected by Gates and Bond in 1936 showed no consistent tendency of eye preference, single eye superiority in acuity, hand preference, or any combination thereof, to be related to reading achievement, reversal errors or visual perception of various items.

Results of a 1967 study by Stephens, et al (Weintraub, 1968) showed that subjects with crossed eye-hand preference had no greater difficulty with reading readiness measures than did children exhibiting unilateral eye-hand preference.

Associated results were also obtained by Belmont and Birch (Weintraub, 1968) in that retarded readers were not found to differ significantly from normal readers in any type of mixed dominance. Likewise, Tinker (Weintraub, 1968) could not find any supportive evidence that laterality is a factor in reading disability.

Smith (Weintraub, 1968) could find no significant differences among his retarded and normal readers on tests of eye, hand, foot, and ear preferences. However, he did note that the proportion of retarded readers making

reversals was almost four times greater than the proportion of normal readers exhibiting these reversals.

A study by Balow and Balow (1964) found no significant relationship between eye and hand dominance with regard to reading achievement nor did they find a relationship between the age of establishing hand dominance and reading ability.

In the aggregate it does not appear that eye and hand dominance is a factor either causal or associative in reading disabilities generally or reversals specifically.

Another postulated cause of reading retardation is insecure directional orientation in the visual perception of symbols. Orton (1937) discussed this in terms of static reversals (misreading of letters) and kinetic reversals (misreading of words where one has an inversion in the sequence or spatio-temporal ordering of letters). He limited this impairment of directional sense to symbolic stimuli rather than to all visual stimuli.

Frise's study (1949) led him to conclude that reversals in reading are not due to a special disability, but rather that reversals in reading are a problem in space perception, a confusion between the figure and its ground. Along these same lines a recent study by Elkind, et al (1965) tested the hypothesis that disabled readers would perform at a lower level and show less learning ability on a measure of figural decentration than would average readers of comparable intelligence. This is based on Piaget's theory that perception in the young child is centered, that is, it is caught and held by the dominant aspects of the visual field and that with increasing age, the child's perception becomes progressively decentered in that it is gradually freed from its earlier domination by field affects. The study supported the idea that poor readers have special disability in perceptual decentration.

Several recent studies have touched upon the relationship between perception and retention of temporal order in regard to reading ability. Birch and Belmont (1964) hypothesized that retarded readers are defective in integrating auditory-visual information. Retarded reading subjects performed less well than normals on a problem which required them to identify which act of spatially distributed dots was equivalent to a previously presented set of temporally organized auditory stimuli.

Blank and Bridger (1966) felt that the retarded readers in the above study may not have had difficulty in intermodal transfer but rather in establishing equivalences between temporal and spatial stimuli. These investigators hypothesized that if this were the case, the retarded readers would have the same difficulty in equating stimuli within the same modality as was obtained using the intermodal approach. They found this to be true in their population and believed that the deficit was due to the difficulty that retarded readers had in applying conceptual categories or the correct verbal labels to temporally presented stimuli.

Bakker (1967) investigated the relationship between perception and retention of temporal order and reading ability for two groups of retarded readers, one group averaging two years and the other four years behind the population norms. The more severely retarded readers made significantly more errors in retaining temporal sequences than the less severely retarded readers. However, the results differed with the types of material presented. Significant differences between the two groups were found when meaningful figures and letters were presented, but no significant differences were found when meaningless figures and digits were used.

Katz and Deutsch (1967) hypothesized that retarded readers would exhibit poorer performances than normal readers on a task requiring rapid attentional

shifts between modalities. Cross-modal and ipsi-modal reaction times were measured. The investigators felt that their hypothesis was confirmed. As Blank and Bridger (1966) point out, there is a limitation in the available terminology such that many widely differing tasks are given the same label. Katz and Deutsch used reaction times to lights and sounds in testing cross-modal transfer while Birch and Belmont, in the study mentioned above, used a very different task.

In considering the problem of serial order in behavior, Lashley (1951) has pointed out the essential interchangeability of spatial and temporal order in cerebral action. In his opinion, both emerge from the same neurological mechanism and, as it were, are two aspects of a single perceptual process.

To paraphrase Money (1964), the written word is a visual image which takes on meaning as a result of the sequential arrangement in space of its component images. To reverse the letters destroys the identity of the word. The positional sequence of alphabetical characters is of paramount importance. To acquire a reading vocabulary one must build and maintain an inventory of visual patterns, all taken from the same alphabetic components but distinguishable from one another by reason of the sequential arrangement of the components.

In reading aloud the student must report on the order of things (letters and words) in space. Since, in the act of reading, there exists a high, but not absolute, correspondence between the spatial and temporal order of events, it seems reasonable that some confusion as to primacy could arise between the two orders when they differ. The present study is designed to cast some light on the existence and nature of this confusion.

# SECTION II

## METHOD

Subjects. Seventy-two children were obtained from the Birdville School District of Fort Worth, Texas, to serve in this capacity. One fourth of this sample (18 subjects) was obtained from each of the third, fourth, fifth and sixth grade levels respectively. For each grade level one half of the members (9 subjects) were judged from grade records and teachers' reports to be normal or superior readers. The remaining nine subjects of each grade level were judged on similar criteria to be retarded readers. These eight sub-groups (third grade normal, third grade retarded, fourth grade normal, fourth grade retarded, fifth grade normal, fifth grade retarded, sixth grade normal and sixth grade retarded) were obtained and tested as described below.

Stimuli. These consisted of 450 motion picture film strips varying from 3 to 15 frames in length. The presentation of a film strip at the exposure rate of 16 frames/sec. constituted a trial; thus, each subject received 450 trials. These trials were varied in the following ways:

1. The letters shown. All of the 26 letters of the English alphabet were used repetively. On each trial 3 letters were shown in an horizontal array. It was the task of the subject to identify and repeat which letters were included within the triad shown.

2. Instructions given. Since the letters were not always shown simultaneously, which is to say that the triad was incomplete on certain frames of the film strip, two different instructions for reporting the letters could be given. The subject could be asked to read from left to right or he could be asked to read in the order of the initial appearance of the letters. The example given below a 7 frame film strip is provided for the purpose of illustration.

| | | POSITION | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| | 1 | | | F |
| F | 2 | | | F |
| R | 3 | | O | F |
| A | 4 | | O | |
| M | 5 | M | O | |
| E | 6 | M | | |
| | 7 | M | | |

It will be seen that the correct response in reading from left to right (spatial instruction) is MOF, while reading under the instruction to report the temporal appearance of the sequence, (temporal instruction) the response FOM would be the appropriate one. On one half the trials the spatial instructions were given while on the remaining trials the temporal order was requested.

3. Order. Considering that there are three positions in which the letters of a triad could occur, there are six permutations available for order of appearance. These are 1-2-3, 1-3-2, 2-1-3, 2-3-1, 3-1-2, and 3-2-1. In the illustration given above the order 3-2-1 is shown.

4. Number. The number of frames in which a letter of the triad appeared, varied from five to a single frame. For any given trial, however, the number of frames per letter was constant. In the illustration above this number is three.

5. Separation. This stimulus variable refers to the number of frames separating the initial presentation of the first letter from the initial presentation of the second letter as well as the number of frames separating the second and third letters. Separations of 1, 2, 3, 4, and 5 frames were

utilized. This meant that when separation was greater than number, blank frames occurred between letters. As illustrated above the separation is two.

6. Pronounceability. This variable emphasized the position or order of a vowel if it occurred as one of the letters of the triad. On one third of all the trials it was insured that a vowel appeared in the second spatial position. On a second third of the trials a vowel occurred as the second letter to appear in the temporal sequence. On the remaining trials the triad did not include a vowel. This variable was added in view of the fact that words are easier to pronounce if the consonants are separated by a vowel as well as in test of the hypothesis that a pronounceable letter sequence containing a middle vowel can be reported more easily than can an unpronounceable one.

These stimuli were produced using animated motion picture techniques on 8 mm. film. The variables of order, number, separation, and pronounceability were treated with orthogonal systemization. Since there were 6 orders, 5 numbers, 5 separations, and 3 pronounceability possibilities, a total of 6 x 5 x 5 x 3 = 450 film strips or triads were required. The variables of letters shown, instructions given, and the subjects were randomly counterbalanced.

Procedure. The film strips were randomly assorted into two separate sequences and spliced together. Enough blank film was spliced between each trial to give the subject sufficient time to respond before the initiation of the subsequent trial.

Testing was conducted in two stages. First the subject was seated facing a screen and given either the instruction to read from left to right or to read in the order of appearance. The projector was started and the subjects read aloud. These responses were recorded by the experimenter. When the roll of film was exhausted, the second roll was mounted and the alternate

instructions of those originally given were then presented. The second sequence was shown and the responses recorded as had been done for the first stage of the experiment.

Response Criteria. The individual answer sheets were scored using four criteria. These are described below.

1. Errors of Inversion. From earlier work of a similar character, as well as from observations of poor readers, it was believed that the tendency to make inversions of correctly identified letters would produce the most sensitive measures of variation to be found in association with reading ability. Using this criterion, if the correct response, for either instruction situation was ABC, but if the subject reported BAC, a penalty of one was given. The response CAB would invoke a penalty of two since that is the number of inversions present. On the same basis three penalty points would be assessed to the response CBA. In scoring for this criterion, no recognition was given to letters not reported, errors of omission, or to the reporting of letters not included in the presentation. Thus DCB and _CB both received a penalty of only one for this method of assessment.

2. Errors of position. As a separate variable it was believed that the accuracy in reporting letters in their proper order, whether the order was positionally or temporally defined, would also prove sensitive. This criterion is similar to that of inversion but not identical with it. The response CBA, for example, contains three errors of inversion but only two for position. Similarly, the response BAC would obtain a penalty of one for inversion while the penalty for position would be two.

3. Errors of commission. This variable related to the inclusion of letters in the response which did not occur in the stimulus. Thus, the report MCA was given a penalty of one while _CA obtained no penalty under this criterion.

4. Errors of omission. This criterion was applied without reference to order. Thus neither CBA nor CAB would have received a penalty. However, C_B would receive a penalty of one under this criterion.

Scores based upon the four response criteria were obtained for each subject under the two instruction conditions of the experiment. The ratio of errors made under the spatial instruction condition to errors made under both the temporal and spatial instruction conditions were then obtained. It was these ratios along with the raw scores obtained under the two instruction conditions which were treated as the dependent variables of the experiment.

# SECTION III

## RESULTS

The mean scores for the eight sub-groups of the experiment made for errors on inversion, order, commission and omission are shown in Table I. These are separated to show the scores obtained under the instructions to read from left to right (spatial) and the instructions to read in the order of appearance (temporal). Also shown is the ratio of temporal errors to total errors (T/T&S).

The statistical significances of the differences between these means are shown in Table II which represents a compilation of the F scores from 12 analyses of variance based upon the product of the five criteria and the three measurements under each criteria.

In general the following statements appear to be valid based upon the statistical significance of the tests performed:

1. There is no difference of statistical importance between normals and retarded subjects using temporal instructions.

2. The difference between normals and retardeds on spatial instructions is always significant except for errors of commission. The difference favors the normals.

3. The difference between the normals and the retarded using the ratio (T/T&S) is always significant except again in the case of errors of commission. These are the critical tests of the hypotheses under investigation. The results of this experiment do, therefore, strongly support this hypothesis.

4. As would be expected, the differences between grades is in favor of the higher levels for all measurements of significance.

5. In two instances the interactions (T/T&S, under order and temporal instruction under errors of commission) are significant.

## TABLE I

Mean error scores for the criteria inversions, order, omissions and commission for the normal and retarded 3rd, 4th, 5th and 6th grade students for the temporal and spatial instructions. Also shown are the ratio of errors obtained under these instructions.

### INVERSIONS

| | Normal | | | | | Retarded | | | |
|---|---|---|---|---|---|---|---|---|---|
| Grade | 3 | 4 | 5 | 6 | | 3 | 4 | 5 | 6 |
| Temporal | 30 | 27 | 23 | 19 | | 33 | 28 | 23 | 22 |
| Spatial | 30 | 17 | 18 | 12 | | 38 | 36 | 30 | 25 |
| T/T&S | .48 | .65 | .57 | .67 | | .46 | .44 | .42 | .44 |

### ORDER

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temporal | 31 | 25 | 21 | 20 | | 34 | 29 | 22 | 18 |
| Spatial | 28 | 20 | 21 | 13 | | 38 | 35 | 28 | 24 |
| T/T&S | .54 | .59 | .50 | .64 | | .47 | .44 | .42 | .43 |

### OMISSION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temporal | 12 | 8 | 8 | 6 | | 14 | 10 | 9 | 7 |
| Spatial | 13 | 10 | 7 | 5 | | 14 | 12 | 12 | 10 |
| T/T&S | .48 | .44 | .53 | .55 | | .50 | .45 | .43 | .40 |

### COMMISSION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temporal | 6 | 6 | 5 | 3 | | 7 | 7 | 5 | 6 |
| Spatial | 7 | 6 | 6 | 4 | | 7 | 7 | 6 | 6 |
| T/T&S | .45 | .50 | .45 | .51 | | .50 | .49 | .47 | .47 |

TABLE II

F scores from 12 analyses of variance for readers, grades and their interactions for errors of inversion, order, omission and commission under the temporal, spatial and ratio conditions. Each is shown in ratio to the within variance obtained under the analysis***.

| Criteria | | F - Scores Temporal | Spatial | T/T&S |
|---|---|---|---|---|
| Inversion | Readers * | .40 | 24.18+ | 24.74+ |
| | Grades ** | 3.02 | 5.99+ | 1.85 |
| | RXG ** | .04 | .62 | 2.27 |
| Order | Readers * | .54 | 27.00+ | 32.39+ |
| | Grades ** | 7.86+ | 8.12+ | .66 |
| | RXG | .27 | .67 | 3.50++ |
| Omission | Readers * | 2.87 | 23.83+ | 4.19++ |
| | Grades ** | 16.67+ | 17.05+ | .46 |
| | RXG ** | .28 | 2.50 | 2.61 |
| Commission | Readers * | 1.62 | 1.29 | .02 |
| | Grades ** | 2.74 | 2.68 | .12 |
| | RXG | 5.44+ | .96 | .19 |

* df's = 1
** df's = 3

*** The df's for the within variances were 64 making the total df's equal to 71 in each test.

\+ > 99% level of confidence.
++ > 95% level of confidence.

## SECTION IV

## DISCUSSION

That the normal subjects were superior to the retarded subjects in reading from left to right comes as no surprise since that after all is the fundamental requirement in reading. Were the difficulty in reading, however, due to an inability to perceive the letters, one would expect a similar finding when the subjects were required to read in the temporal order of occurrence. This did not happen. Retarded readers do about as well as normal readers in this respect.

If poor reading is not a matter of perceiving the letters, then it is reasonable to suppose that the difficulty arises in organizing them. The evidence of this experiment strongly supports this conclusion. The ratio of temporal errors to total errors are generally lower for the retarded subjects. The hypothesis under investigation is in consequence confirmed. It seems altogether likely that at least some of the difficulty in reading is due to the inability of some readers to reorganize their experiences in time into its proper spatial form.

Although the results are highly suggestive that this type of disorganization is an important factor in reading disability, the present experimenter at this moment cannot, in candor, recommend a therapeutic procedure to eliminate the difficulty. Some training methods suggest themselves, but it is impossible to know, without additional investigation, how successful they would prove to be. The present line of investigation should, however, be continued with a stronger emphasis on classroom application.

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